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January 27, 2011

Mr. Paul Kalaiwaa
Hawaii Department of Health
Hazardous Waste Division
P. O. Box 3378
Honolulu, HI 96801

**RE: Remediation Report - Free Floating Product Plume**
**(HID 056 786 395)**

Enclosed is the Remediation Report for the Free Floating Product Plume at the Tesoro Refinery in Kapolei Hawaii dated January 26, 2011 that updates the remediation progress through December 31, 2010.

In a letter dated August 12, 2003 regarding the June 21, 1993 Corrective Action/Final Order (HID056786395), the EPA confirmed that all mandatory corrective measures have been satisfied and prospective over-sight responsibility for the plume has been delegated to the state. Even so, based on prior requests, we are providing a copy of the 2010 report to the EPA as well.

If you have any questions regarding this report please call Walter Albertson at (808) 479-0521.

Sincerely,

Theodore K. Metrose
Manager, Refinery Environmental Affairs

Attachments

CC:

Mr. Mitch Kaplan
U.S, EPA Region IX (H-3-1)
75 Hawthorne Street
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BCC: Department– RCRA 13.4 FREE PRODUCT MGMNT PROGRAM Remediation Reports

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# Remediation Report

# for the

# Free Floating Product Plume

# at
# Tesoro Hawaii Corporation Refinery

91- 325 Komohana Street
Kapolei, Hawaii 96707
(EPA ID HID056786395)

January 26, 2011

Prepared By:

Walter Albertson

## 1.0 Introduction / Executive Summary

This Remediation Report provides an update as of December 31, 2009 of the measures that have been implemented to address the free product plume at Tesoro Hawaii Corporation (Tesoro) refinery located in the Campbell Industrial Park in Kapolei, Hawaii.

On June 21, 1993, EPA Region 9 and BHP Petroleum Americas Refining Inc. (BHPPAR) entered into a Corrective Action Consent Agreement and Final Order (CA/FO). The obligations and requirements of the CA/FO where assigned to Tesoro when it acquired all of the stock of BHPPAR and the refinery in July of 1998. The CA/FO required that the following three corrective actions be executed:

- RCRA Facility Investigation (RFI)
- Corrective Measures Study (CMS)
- Corrective Measures Implementation (CMI)

The corrective actions for the free product plume, formalized in the CA/FO, were originally triggered because the refinery had previously operated 3 waste water treatment ponds (surface impoundments) under RCRA interim status which had to be closed. Closure and post closure plans were prepared, submitted and ultimately approved by the EPA. The 3 ponds were closed and are now capped with an impermeable layer of asphalt. Post closure monitoring of the groundwater surrounding the surface impoundments is continuing (on a semi-annual basis) and the reports related to the closure are being submitted (under a separate cover) annually.

As a consequence of RCRA surface impoundment closure, a facility-wide RFI that was conducted, which led to the determination that further investigation was needed for:

- 10 Solid Waste Management Units (SWMU),
- 6 Areas of Concern (AOC's) and
- a plume of free floating product (weathered diesel) beneath the refinery.

The contaminates identified in these areas, were not similar to nor attributed to the operation of the surface impoundments. Nonetheless, the RCRA closure process effectively forced an investigation and clean up of the entire facility. The RFI report indicated that 2 of the 16 areas, the Fire Training Area and a portion of the Miscellaneous Materials Staging Area contained elevated levels (60 – 200 mg/kg) of arsenic that required corrective action. Nearly 350 tons of arsenic contaminated soil was excavated and disposed in Waimanalo landfill in August 1998, well before the CMS was finalized in February 1999. A Health-based Risk Assessment (HRA) was conducted to determine that residual arsenic levels did not pose an unacceptable risk to humans. Corrective measures for the arsenic contamination are considered complete. All reports related to the arsenic soil clean up have been previously provided and will not be further addressed in this report.

Clean-up of the subsurface diesel plume was addressed principally through the CMI. After conducting a technology assessment, a belt-skimmer recovery system was commissioned on October 24, 2001. In a letter dated August 12, 2003, the EPA acknowledged that all the measures required by the CMS/CMI had been sufficed and that oversight responsibility had been shifted to the DOH.

Even prior to the CMS/CMI, the diesel plume was addressed through a series of corrective and preventative measures. The preventative measures implemented to date include the following:

1. Major portions of the oily water sewer system were relined in 1995

2. Operational procedure have been altered such that oil bearing materials are no longer placed directly on the ground

3. Improved procedures for responding to oil spills

4. Since the CA/FO, and as of December 31,2010 fifty-four (54) petroleum storage tanks have been double bottomed, including the three crude oil tanks which were specifically required by the consent agreement and one in 2010.

5. In 1990, well before the CA/FO, one tank (110) had been double-bottomed. Also, in 1990 the four tanks in the north tank farm were originally built on concrete pads.

6. Cracks in concrete and asphalt covered portions of the refinery continue to be identified and filled with a special sealant, as needed

7. Additional asphalt has been placed on portions of the refinery to prevent hydrocarbon spills from reaching the groundwater. There have been no additional areas asphalted in 2006 through 2010.

A significant effort and capital has already been invested in the last four of the preventative measures described above and those initiatives are set to continue into the future.

In addition to the preventative measures described above, corrective measures have been implemented to assess and mitigate any negative effects that may be attributed to the free product plume. The corrective measures implemented to date include the following:

1. In September 1996 consultants, Dames and Moore prepared a report on summarizing the free product management program, (FPMP). Well data was reviewed and a recovery test was conducted. The free- floating hydrocarbon was characterized as a weathered diesel containing comparatively little residual VOCs.

2. A short-term remediation test involving a number of different technologies was completed in June 1997. The technology evaluation was compiled in the CMS.

3. A free product and tidal study was conducted to determine the influence of the tide on the flow of groundwater and the impact on the free product plume. In addition to reviewing historical data, an intensive (round-the-clock) sampling effort was conducted during a three-day period in December 1998.

4. Six (6) additional ground water monitoring wells were drilled and installed in January 1999, within the refinery's central processing area. The extent and the size of the plume were further delineated by level sampling the new and previously installed wells.

5. Sophisticated models were employed to estimate the amount of the free product as between 240,000 - 340,000 gallons.

6. A long-term pilot test of the Abanaki PetroXtractor belt skimmer system was conducted. In August 1999, a belt skimmer was installed on monitoring well BHP-MW8. Nearly 5700 gallons of oil was recovered, as of March 2001.

7. Fifteen (15) additional wells were drilled in June 2001 for delineation and recovery.

8. Ten (10) of these wells (for a total of 11 wells) were equipped with Abanaki belt skimmers as part of the full-scale free product recovery system. The skimmers were mani-folded to a recovery tank and level controlled pump in September 2001.

9. The free product recovery system was placed into service on October 24, 2001. Beginning in mid-2005, there were also several belt skimmers that were incrementally taken out-of-service due to plugging, corrosion and/or poor recovery. As of December 29, 2010, a total of 176,180 gallons of liquids have been recovered of which approximately 74,538 gallons appears to be oil.

10. The free product recovery system was temporarily shut down on April 10, 2006 because the oil gathering pipeline was severely corroded. Over 900 feet of carbon steel piping was replaced with fiber glass reinforce plastic (FRP) piping. The upgrade was completed on February 12, 2007, at a cost of nearly $100,000.

11. Eight (8) new monitoring wells were drilled within the northwest area of the refinery in January of 2008. The delineation wells were installed because oil was encountered while drilling foundation test holes in the Spring of 2007 for the Electrical Reliability Upgrade Project. Two (2) wells just south of Komohana St have free product suggesting that the oil plume extends beyond the northern property line. Over the past two years the two wells on the northwest edge of the property boundary have averaged 0.50 ft oil depth.

This Remediation Report will focus on the free product recovery project since the CMS and other issues have already been addressed in earlier reports.

# 2.0 Background

## 2.1 Facility Location/Site Setting

The Tesoro refinery is situated in the Campbell Industrial Park at Barbers Point, approximately 22 miles west of Honolulu (Figure 1 – Refinery Location). The industrial park includes commercial and both heavy and light industrial facilities. The Tesoro refinery is bounded on the north and west sides by other occupants of the industrial park, on the east side by a storm drainage canal and the former Barber's Point Naval Air Station (NAS), and on the south side by a vacant lot on which cattle feed lot was formerly located (Figure 2 – Refinery General Map). The Ewa Plain area surrounding the facility consists of a population of approximately 258,000 residents. The nearest residential communities are Makakilo and Kapolei located 3 and 2.5 miles to the northeast of the refinery respectively. The community of Waianae is located approximately 5.5 miles to the west of Campbell Industrial Park. The nearest school is located 1.25 miles to the east at the former NAS.

## 2.2 Refinery Operations and Ownership History

The refinery, whose operations began in 1972, was owned and operated by the Hawaiian Independent Refinery, Inc (HIRI), a wholly owned subsidiary of Pacific Resources, Inc. (PRI). In 1989, Broken Hill Proprietary Ltd. acquired all of the stock of PRI and, subsequently, changed the corporate names of PRI and HIRI to BHP Hawaii Inc. and BHP Petroleum Americas Refining Inc. (BHPPAR), respectively. In 1998, Tesoro Petroleum Corporation acquired all of the stock of BHPPAR from BHP Hawaii Inc. and changed the corporate name of BHPPAR to Tesoro Hawaii Corporation, which remains the current owner/operator of the refinery. The Tesoro refinery currently produces various products such as naphtha, kerosene jet fuel, reformate, gasoline, propane, butane, fuel gas, fuel oils, diesel fuels, asphalt, and sulfur.

# 3.0 Regulatory Overview

Three wastewater treatment ponds (impoundments) had previously operated under RCRA interim status beginning in 1981. Following oil / water/ solids separation, these ponds were used to further treat and store refinery process wastewater. The adoption of two regulations effectively caused the wastewater and sludge held in these ponds to be recharacterized as hazardous waste and forced closure of the ponds. On September 25, 1990, when the Toxic Characteristic Leaching Procedure (TCLP) replaced the Extractive Procedure (EP) as the toxicity criteria, waste water and sludge containing low levels of benzene were considered hazardous. On November 2, 1990 the EPA added Primary and Secondary Oil/Water/Solids Separation Sludge (F037 and F038) to the list of hazardous waste from the refining industry. A closure plan for one of the impoundments was submitted to EPA in August 1986. Closure plans for the other two impoundments were submitted

to EPA on September 13, 1991. A revised closure plan for the first impoundment was submitted to EPA on July 12, 1993. EPA approved the closure plans on October 31, 1994 and the ponds have since been closed, and replaced by a Wastewater Treatment Unit consisting entirely of above-ground tanks. Post closure ground water monitoring for the closed pond continues as required by the EPA approved closure/post closure plan and approved ground water monitoring plan.

A Consent Agreement/Final Order (CA/FO) was entered into on June 21, 1993 by BHPPAR. This order incorporated corrective action requirements under RCRA 3008(h). The refinery was required to conduct a RCRA RFI of the entire site. The RFI was completed with EPA approving the RFI final report on October 30, 1998. The RFI investigated 10 Solid Waste Management Units (SWMUs) and 6 Areas of Concern (AOCs) located throughout the facility. The CA/FO also required the refinery to design and implement a Ground Water Monitoring Program (GMP) and submit a final report. This report was submitted to EPA on March 19, 1996 and was approved by EPA on June 10, 1996.

# 4.0 Environmental Setting

## 4.1 Geology

The refinery is located on the Ewa Plain which consists of two geologic provinces; the inland and seaward provinces. The refinery is located in the seaward province, which is made up of marine sediments and exposed limestone (elevated coral reefs). Soils are mostly derived from the underlying coral and are typically a few feet thick. Most soils consist of coral and cemented calcareous sands with a small portion consisting of red, friable, silty sand.

## 4.2 Hydrogeology

The upper 300 feet of the Ewa Plain is divided into 3 principal water-bearing units of which the uppermost unit is the focus of concern. The shallowest water bearing unit, known as Aquifer 1, ranges from approximately 11 to 110 feet below ground level. The upper portion of this aquifer is further differentiated in the vicinity of the refinery into what is called the Uppermost Aquifer, which ranges from approximately 11 to 55-65 feet below ground level. A brown silty layer (Uppermost Aquitard) is found immediately below the Uppermost Aquifer and ranges from 5 to 10 feet thick. Ground water within the Uppermost Aquifer is classified as brackish/saline with TDS concentrations ranging from 20,000 to 150,000 mg/l. Increasing salinity has been measured with depth. Ground water flow is generally to the southwest beneath the refinery, with velocities measured at 0.6 feet /day (Dames and Moore, 1997) but is affected by tidal influences, operation of off-site pumping and injection wells, and a storm drainage canal located at the eastern boundary of the refinery. Hydraulic conductivity (K) has been measured on a regional and local scale. Regionally, K values from the literature range from 4,000 - 5,000 feet/day (ESE, 1996). Average measured hydraulic gradients range from 0.0001 (Harding-Lawson Associates, 1987) to 0.0009 (Levine-Fricke, 1993). The uppermost aquifer is influenced by the tide. However the tides influence is not universal because of heterogeneity of the shallow strata.

### 4.3 Surface Water

The Pacific Ocean is located less than 1500 feet south of the refinery. There are no lakes, rivers or streams in the area of Campbell Industrial Park. Along the eastern border of the refinery there is a storm water channel, which serves portions of Makakilo, Kapolei and Campbell Industrial Park. Rain falling on the refinery infiltrates either directly to the subsurface or accumulates in the refinery's storm drainage system from which it either evaporates or infiltrates to the subsurface. Only during extreme storm events will storm water run-off site into the storm water channel.

## 5. 0 Summary of the Problem- RCRA Facility Investigation (RFI)

As required under the CA/FO, an RFI was conducted for the entire Tesoro refinery addressing soil and ground water contamination throughout the entire refinery area. The refinery has voluntarily addressed a light non-aqueous-phase liquid (LNAPL) plume, also known as the free product plume through preventative and remedial efforts. The plume is composed primarily of weathered diesel range hydrocarbons with practically no measured volatile constituents. The free product plume was initially estimated to contain between 240,000 and 360,000 gallons when it had a thickness ranging from a sheen to approximately 1.2 feet. Estimates of the size of the plume have changed over time as additional wells have been drilled and subsurface models have been enhanced. Tidal effects and rain infiltration, which influence the saturation of the shallow formation, have challenged modeling efforts. The free product plume is located near the center of the property, does not appear to be migrating at present. Prior to drilling an additional 15 wells in 2001 for the full-scale recovery project, the CMS depicted the free product plume as shown in Figure 3.

## 6.0 Corrective Measures Implemented

The approach taken by the Tesoro refinery for corrective action at its facility differs significantly from the standard approach used at most RCRA-regulated facilities. The refinery voluntarily undertook a series of preventative measures beginning in 1995 that addressed the free product plume beneath the refinery.

- major portions of the oily water sewer system were relined in 1995
- Fifty-two (52) petroleum storage tanks have been double bottomed as of 12/31/09
- cracks in concrete and asphalt covered portions of the refinery were identified and filled with a special impervious sealant
- additional asphalt has been placed on portions of the refinery to prevent hydrocarbon spills from reaching the groundwater. In addition to implementing measures designed to prevent existing or new sources of hydrocarbon from contributing further to the plume, the refinery initiated a procedure for remediating and containing the plume. The RFI, which identified contamination throughout the refinery, including but not limited to the product plume, was completed in 1998. Alternatives for remediation of the free-floating product were evaluated in the Corrective Measures Study, issued in February of 1999.

## 6.1 Plume Delineation and Characterization

An investigation of the nature and extent of free product beneath the refinery has been conducted. Since 1987 approximately 86 shallow wells have been drilled on refinery property to determine size and the location of the plume and to monitoring the quality of water around the ponds. In 1999, six wells were drilled centrally within the main process areas of the refinery and most recently in June of 2001, another 15 wells were drilled, as part of the remediation project. The size and location of the plume depicted in Figure 4 – Well Location Site Plan 2001 Free Product Thickness was updated (from earlier versions) based on the additional data collected after drilling 15 new wells for the full-scale recovery project in the summer of 2001. As a consequence, Figure 4 may be considered as the baseline prior to significant recovery/remediation efforts. Notably the additional information obtained by measuring the oil thickness over time and from the additional wells drilled in 2001 and 2008, suggests that the plume may not be quite as large or as widespread as reported in the CMS.

Although natural attenuation and the recovery measures discussed in section 6.5 appear to have reduced the maximum thickness of the subsurface plume, the basic size and the shape of plume as depicted in Figure while is basically unchanged, may be more appropriately represented as two smaller plumes.

In Dames and Moore's 1996 Free Product Management Program Report 6 samples of the LNAPL had an average Total Petroleum Hydrocarbon (TPH as diesel) content of 93.8%. Similarly in the RFI, the free-floating product had been characterized as a weathered diesel with relatively few residual volatiles. That assessment was again confirmed by analyzing the free product from the (long term pilot) recovery well discussed in section C.3. The sample collected on May 15, 2001 indicated the free product was all diesel with little VOC's. The BETX results from the May 15, 2001 recovered oil sample are provided below.

| Compound | mg/kg |
|---|---|
| Benzene | < 100 detection limit |
| Ethylbenzene | 349 |
| Toulene | < 100 detection limit |
| Xylenes (tot) | 1,000 |

See the CMI report dated May 31, 2002 for copies of the actual lab reports.

Besides the BETX there were other VOCs in the recovered oil, the two largest of which are listed below.

| Compound | mg/kg |
|---|---|
| 1,2,4- Trimethylbenzene | 2440 |
| Naphthalene | 2640 |

Absence of significant VOCs in the recovered oil sample may be attributed to the initial composition of the product that was released. In addition, volatile fractions originally present in the released hydrocarbon may have been biodegraded and/or volatilized, through the overlying strata to the atmosphere. In either case the fact that the free floating product has remained void of light ends,

strongly suggests that the preventative measures have been effective in precluding additional liquid hydrocarbons from leaking to the soil and contributing to the plume.

On December 28, 2004 oil samples were taken from wells MW-4 and BHP MW7A with diesel range organics results of 82.6% and 82.0% respectively. The oil from both wells was also analyzed for gasoline constituents and the results indicated that if present they were below the method detection limits (1000 mg/kg).

In the spring of 2007, test and pilot holes for the Electrical Reliability Project were drilled along the northern border of the refinery next to the Control Room. Oil was encountered in a number of those wells. To better delineate the extent of the plume, eight permanent monitoring wells were installed in the Northwest quadrant of the refinery, in early 2008. Over the past two years the two wells on the northwest edge of the property boundary have averaged 0.50 ft oil depth.

The plume depicted in Figure 5 has been updated to reflect quarterly monitoring data from all wells including the eight new monitoring wells installed in 2008. The two new wells drilled just south of Komohana Street suggest the free product plume to extend beyond the refinery's property line to the north and up-gradient of the process unit.

Figure 5 also represents the possibility of two distinct plumes, one beneath the refinery process units and one near the closed ponds (surface impoundments) near Tank 902. No significant hydrocarbons were detected in the new wells installed along the western property line.

## 6.2 Technology Evaluation /Test

Technologies for mitigating the effects and controlling the plume were also evaluated on a voluntary and expedited basis. Tesoro has conducted its investigation on a voluntary basis and has subsequently reached agreement with the EPA to pursue corrective measures under the procedures outlined in the CA/FO and the CMS, including selection and implementation of appropriate corrective measures.

First an evaluation of remediation technologies was conducted. Short-term pilot tests were conducted in May and June of 1997. Three active and three passive recovery methods were evaluated. Of the six removal methods evaluated, the system referred to as the Abanaki PetroXtractor, which is a motor driven belt skimming device, was the simplest to set up and most economical to operate. The test and evaluation of the various technologies and approaches is detailed in the CMS.

## 6.3 Long Term Pilot Test

A longer-term pilot test of the belt skimmer to determine the effectiveness of free product removal as a function of aquifer yield and the efficiency of the removal equipment were conducted. An Abanaki belt skimmer was installed on groundwater monitoring well BHP-MW8.

Actual oil recovery began in August 1999. Approximately 5700 gallons of oil had been recovered from the BHP-MW8 well as of March 2001 at an approximate rate of 10 - 40 gallons per day. Oil collected from the pilot system was separated from the water phase, and collected in a 55-gallon drum. The drums were periodically emptied using a vacuum truck and the recovered oil was returned to the crude units for processing.

Even though a reduction in the thickness of LNAPL could not be quantified, the amount of oil being recovered demonstrated the viability of the belt skimmer system. The pilot test was suspended shortly before the full-scale system was installed.

## 6.4 Full Scale Recovery System

With the review and approval of the EPA, and at a cost of over $330,000 in the summer of 2001, Tesoro installed a full-scale recovery system. The full-scale recovery system includes recovery wells, belt skimmers and a recovery tank. In June 2001, 15 wells were drilled approximately 125 feet apart, in a "J" configuration around the 200 and 400 series tanks. To ease access and ensure their safe operation, the wells were drilled along the side of refinery roads (2nd, C, and D Avenues), just south of the refinery's main process areas. The wells were located, within the plume but slightly down gradient of the plume center, to prevent the plume from moving beyond the refinery's property line.

Abanaki belt skimmers were installed on 10 of the 15 wells, which appeared to have the greatest oil thickness. The Initial oil thickness in the recovery wells ranged from 1.2 feet to just a sheen. The original test pilot well (BHP-MW8), which was already equipped with a belt skimmer was also connected to the manifold system, making a total of 11 wells, being equipped with belt skimmers.

A 2-inch oil collection header is used to manifold the wells together and allow the recovered oil and water to gravity drain from the belt skimmers to an above ground tank (Tk 1299) that was installed specifically for this project. Although the belt skimmers are equipped with an oil water separator, they have been disabled so that any groundwater that is carried to the surface with the skimmer is also recovered and treated. Initial analysis of the subsurface water indicated it contained trace (ppb) levels of certain VOC's (1, 2,-4 TMB and naphthalene). The small (180 gallon) recovery tank is equipped with a level-actuated 3 gpm centrifugal pump. An electrical switch panel is used to control the operation of belt skimmers, provide for an emergency shutdown, and control the operation of the pump. When tank 1299 level reaches 23 inches of height, the oil and water are pumped, through a totalizing flow meter ( FI1297) to off-spec Tank 110. Once the level of Tank 1299 is drawn down to 2 inches the pump is automatically turned off, and recovered liquid levels begin to accumulate again.

To protect employees and to control organic vapors the closed-top oil recovery tank is routed through a carbon canister before being vented to atmosphere. The carbon is periodically checked to determine if it needs to be replaced. The recovery tank was built on a concrete pad that is curbed to provide secondary containment.

The oil and water recovered from the belt skimmers is routed from Tank 1299 to Tank 110 and commingled with liquids of a similar composition from other sources within the refinery. Hydrocarbons from tank 110 are routed to the crude tanks and fed in to the crude distillation tower. The water phase from Tank 110 is routed to the refinery's Wastewater Treatment Unit (WTU). The WTU consists of primary oil/water separation, air stripping and aggressive biological treatment. After treatment in the WTU the water collected from the belt skimmer is injected into one of two 230' deep wells, which are operated pursuant to a state issued Underground Injection Control (UIC) permit (UO-319).

## 6.5 Recovery and Impact

Since the full-scale recovery system has been commissioned from October 24, 2001 through December 29, 2010 the system has recovered 176,180 gallons of liquids according to the flow totalizer. The liquid is a mix of oil and water. The oil cut has varied between 100% and 0% during this period, though since 2008 the recovered liquid has been 46-71% oil due to belt material selection. The recovery system was shutdown in April 2006 due to a severely corroded pipeline from the belt skimmers to the oil recovery tank. Most of the skimmers had to be replaced due to severe corrosion and the system was restarted on August 29, 2007. In 2010, 5,895 gallons of oil were recovered for a total of 74,538 gallons of oil recovered since the recovery system was placed in service. System recovery rates and cumulative recovery since inception are indicated in Figure 6 and Figure 7, respectively.

Table 1 –summarizes the measured oil thickness of the monitoring and recovery wells drilled in 1999 and 2001. The average thickness of the plume measured in these 21 wells was 0.44 feet in 2010 compared to an average oil thickness of 0.42 feet in 2002.

As indicated by Table 1 and as graphically depicted in Figure 8, the thickness of the plume does not appear to be materially reduced as a result of the recovery efforts implemented to date. This observation is consistent with the fact that the amount of hydrocarbon recovered represents less than 25% of the amount in place according to estimates provided in the RCRA Facility Investigation.

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**ıess Averages**

**Table 1 subsurface Plume - Free Product Thickness**

| Well | Property | Location | Depth | Screen | Dia | Date Drilled | 2001 avg oil thk (ft) | 2002 avg oil thk (ft) | 2003 avg oil thk (ft) | 2004 avg oil thk (ft) | 2005 avg oil thk (ft) | 2006 avg oil thk (ft) | 2007 avg oil thk (ft) | 2008 avg oil thk (ft) | 2009 avg oil thk (ft) | 2010 avg oil thk (ft) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TSO99MW-1 | Refinery | W of H175 | 19 | open | 8" | 1999 | 0.82 | 0.77 | 0.77 | 0.76 | 0.75 | 0.77 | 0.74 | 0.79 | 0.83 | 0.73 |
| TSO99MW-2 | Refinery | S of Tk1103/3rd and D | 25 | 15 | 4" PVC | 1999 | 0.87 | 1.15 | 0.49 | 0.60 | 0.70 | 0.75 | 1.10 | 0.95 | 0.96 | 0.97 |
| TSO99MW-3 | Refinery | 3rd & D | 25 | 15 | 4" PVC | 1999 | 0.72 | 0.54 | 0.49 | 0.56 | 0.82 | 0.66 | 0.98 | 0.95 | 0.95 | 0.93 |
| TSO99MW-4 | Refinery | SW of Proc Lab | 25 | 15 | 4" PVC | 1999 | 0.45 | 0.46 | 0.27 | 0.16 | 0.14 | 0.16 | 0.35 | 0.39 | 0.50 | 0.41 |
| TSO99MW-5 | Refinery | NW of H504 | 19 | open | 8" | 1999 | 0.40 | 0.46 | 0.44 | 0.32 | 0.31 | 0.29 | 0.25 | 0.22 | 0.23 | 0.30 |
| TSO99MW-6 | Refinery | SE of Tk2301 | 19 | open | 8" | 1999 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| TSO01RW-2 | Refinery | N of Tk 405 | 25 | open | 8" | 6/4/2001 | 0.09 | 0.36 | 0.08 | 0.11 | 0.13 | 0.18 | 0.06 | 0.00 | 0.01 | 0.41 |
| TSO01RW-3 | Refinery | N of Tk 405 | 25 | open | 8" | 6/13/2001 | 0.73 | 0.59 | 0.38 | 0.59 | 0.44 | 0.57 | 0.55 | 0.54 | 0.34 | 0.55 |
| TSO01RW-4 | Refinery | NE of Tk 401 | 25 | open | 8" | 6/13/2001 | 0.68 | 0.48 | 0.45 | 0.17 | 0.32 | 0.59 | 0.54 | 0.75 | 0.75 | 0.69 |
| TSO01RW-5 | Refinery | NW of Tk401 | 25 | open | 8" | 6/18/2001 | 0.56 | 0.76 | 0.09 | 0.07 | 0.24 | 0.70 | 0.75 | 0.90 | 0.88 | 0.66 |
| TSO01RW-6 | Refinery | S of E603 | 25 | open | 8" | 6/13/2001 | 0.10 | 0.29 | 0.55 | 0.58 | 0.61 | 0.62 | 0.72 | 0.68 | 0.84 | 0.69 |
| TSO01RW-7 | Refinery | NW of Tk 403 | 25 | open | 8" | 6/14/2001 | 0.04 | 0.41 | 0.24 | 0.43 | 0.52 | 0.68 | 0.87 | 0.87 | 0.92 | 0.88 |
| TSO01RW-8 | Refinery | S of Demin 7/8 | 25 | open | 8" | 6/13/2001 | 0.94 | 0.91 | 0.93 | 0.79 | 0.74 | 0.81 | 0.81 | 0.66 | 0.50 | 0.26 |
| TSO01RW-9 | Refinery | S of E907 | 25 | open | 8" | 6/5/2001 | 1.16 | 0.67 | 0.51 | 0.24 | 0.79 | 0.82 | 0.82 | 0.80 | 0.77 | 0.50 |
| TSO01RW-10 | Refinery | N f Tk 203 | 25 | open | 8" | 6/13/2001 | 0.17 | 0.04 | 0.03 | 0.01 | 0.03 | 0.07 | 0.04 | 0.06 | 0.04 | 0.01 |
| TSO01RW-11 | Refinery | along 2nd | 25 | open | 8" | 6/4/2001 | 0.03 | 0.13 | 0.12 | 0.04 | 0.06 | 0.09 | 0.18 | 0.13 | 0.09 | 0.06 |
| TSO01RW-12 | Refinery | along 2nd | 25 | open | 8" | 5/30/2001 | 0.05 | 0.19 | 0.12 | 0.01 | 0.00 | 0.00 | 0.00 | 0.01 | 0.11 | 0.08 |
| TSO01RW-13 | Refinery | along 2nd | 25 | open | 8" | 6/13/2001 | 0.18 | 0.11 | 0.18 | 0.05 | 0.06 | 0.06 | 0.08 | 0.10 | NA | NA |
| TSO01RW-14 | Refinery | Sw of Tk 204 | 25 | open | 8" | 5/29/2001 | 0.21 | 0.14 | 0.19 | 0.14 | 0.13 | 0.13 | 0.13 | 0.13 | 0.24 | 0.27 |
| TSO01RW-15 | Refinery | S of Tk204 | 25 | open | 8" | 5/30/2001 | 0.29 | 0.17 | 0.24 | 0.19 | 0.19 | 0.14 | 0.12 | 0.12 | 0.26 | 0.16 |
| TSO01RW-16 | Refinery | S of Tk202 | 25 | open | 8" | 5/31/2001 | 0.28 | 0.14 | 0.20 | 0.17 | 0.16 | 0.19 | 0.17 | 0.17 | 0.31 | 0.32 |
| Average Thickenss (MW 1-6 & RW 2-16 Benchmark Wells) | | | | | | | 0.42 | 0.42 | 0.32 | 0.28 | 0.34 | 0.39 | 0.44 | 0.44 | 0.48 | 0.44 |

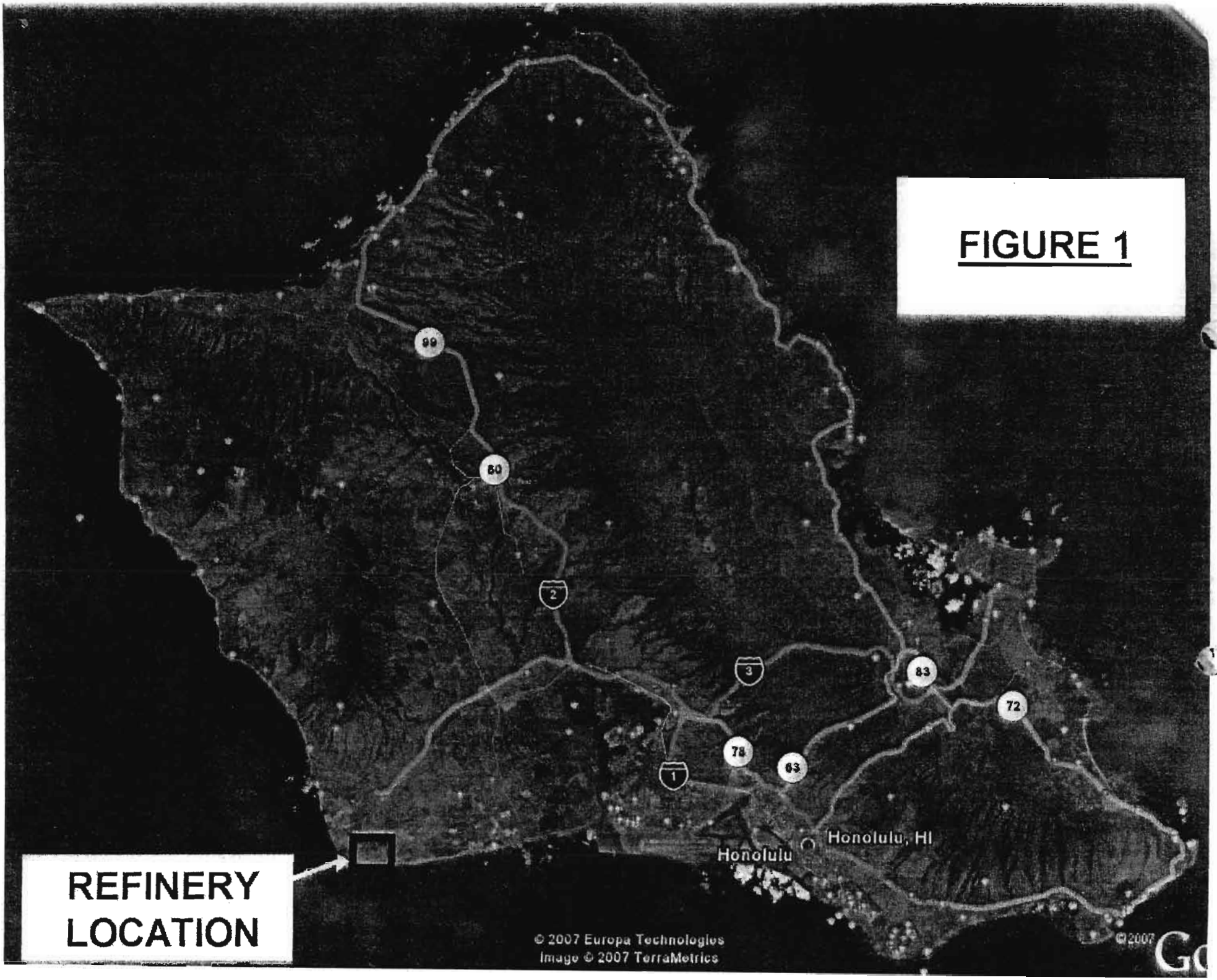
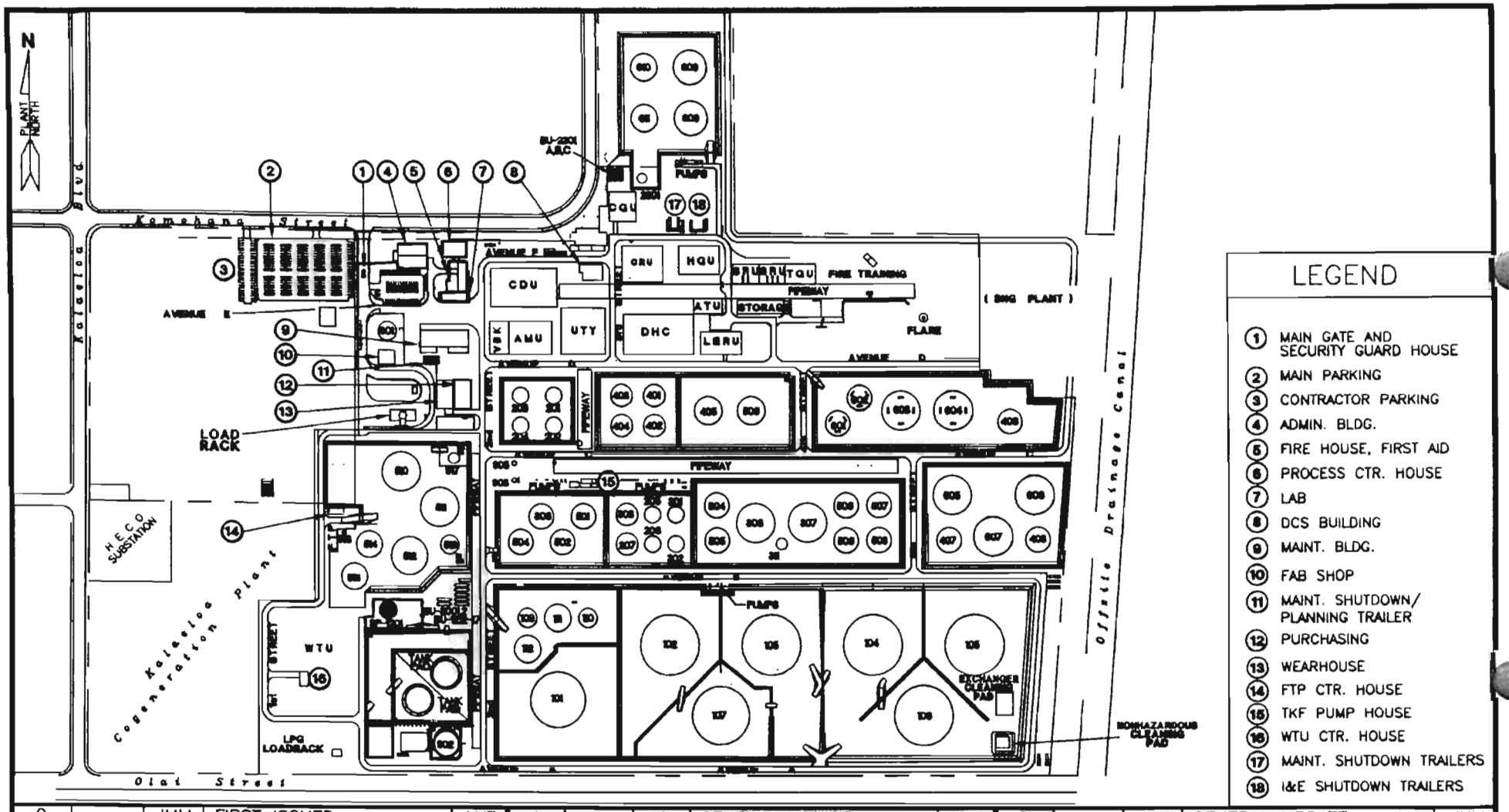


FIGURE 1
99
80
2
3
83
72
78
63
1
Honolulu, HI
Honolulu
REFINERY LOCATION
© 2007 Europa Technologies
Image © 2007 TerraMetrics
© 2007




## LEGEND

1. MAIN GATE AND SECURITY GUARD HOUSE
2. MAIN PARKING
3. CONTRACTOR PARKING
4. ADMIN. BLDG.
5. FIRE HOUSE, FIRST AID
6. PROCESS CTR. HOUSE
7. LAB
8. DCS BUILDING
9. MAINT. BLDG.
10. FAB SHOP
11. MAINT. SHUTDOWN/ PLANNING TRAILER
12. PURCHASING
13. WEARHOUSE
14. FTP CTR. HOUSE
15. TKF PUMP HOUSE
16. WTU CTR. HOUSE
17. MAINT. SHUTDOWN TRAILERS
18. I&E SHUTDOWN TRAILERS

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 5/28/98 | JMM | FIRST ISSUED | MJT | 1 | 5/5/04 | JMM | GENERAL UPDATE | JXM | 2 | 11/1/05 | JMM | GENERAL UPDATE | JXM |

**TESORO HAWAII**

91-325 KOMOHANA STREET
KAPOLEI, HAWAII 96707
TELEPHONE (808) 547-3800

010 – GENERAL
GENERAL ENGINEERING

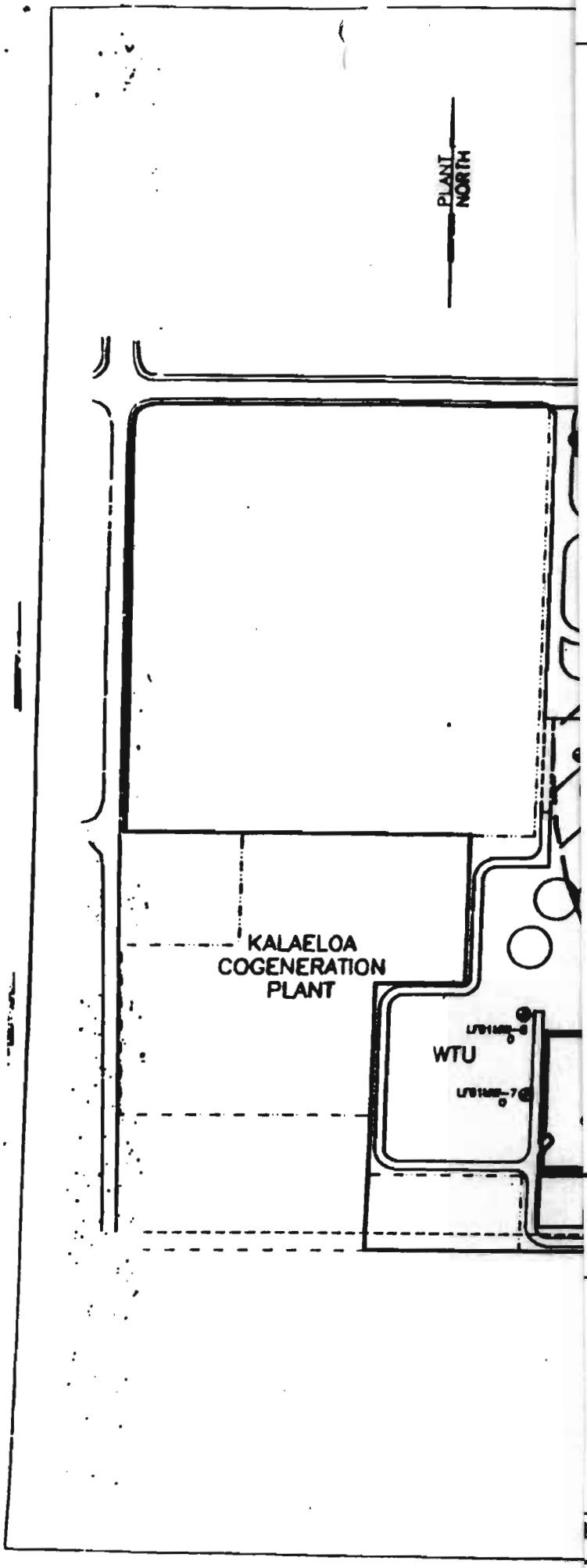
# REFINERY GENERAL MAP

| | |
|---|---|
| DESIGN | JMM |
| DATE | 5/29/98 |
| CHECKED | |
| OPERATIONS | |
| APPROVED | |

SCALE: NONE
PROJECT NO.: –
DRAWING NO.: A-010-C-57
REV.: 2

R:\RECORDS\REFINERY\A-010-C-57.DWG

FIGURE 2




LEGEND:

MONITORING WELL INSTALLED 1999

MONITORING WELL

REFINERY TANK

16 SOLID WASTE MANAGEMENT UNIT

15 AREA OF CONCERN

WTU WASTEWATER TREATMENT UNIT

FREE PRODUCT PLUME (1998/1999)

NOTE:

- THESE HAWAII WELLS WERE RECONSTRUCTED IN 1998 AND HAVE RETAINED THEIR ORIGINAL NOMENCLATURE.

APPARENT FREE PRODUCT MEASUREMENTS

- 0.11 FEBRUARY 1999 MEASUREMENTS
- 0.10–0.35 DECEMBER 1998 MEASUREMENTS
- 0.31 FEBRUARY 1999 MEASUREMENTS

0 175 350 700

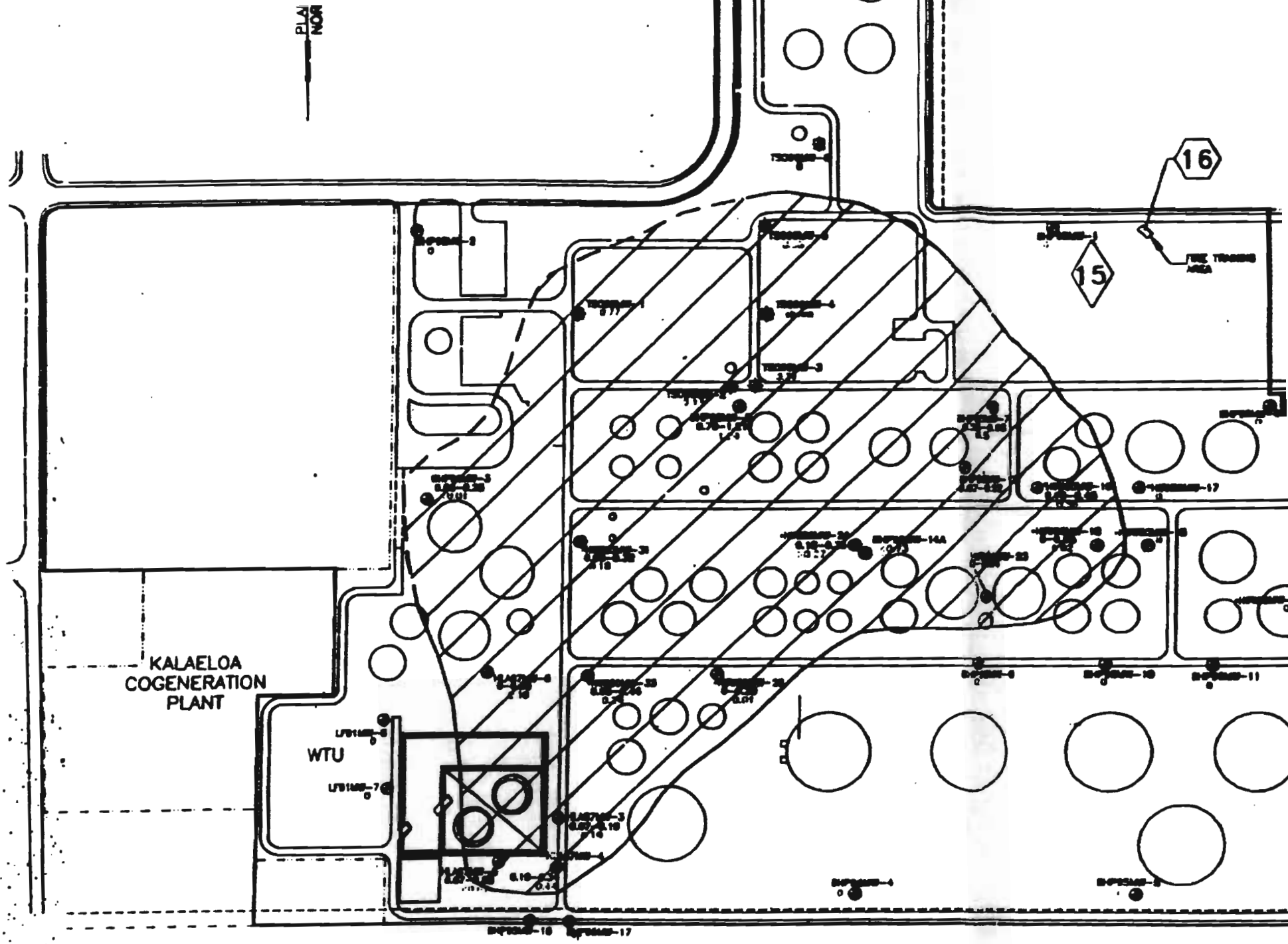
SCALE IN FEET

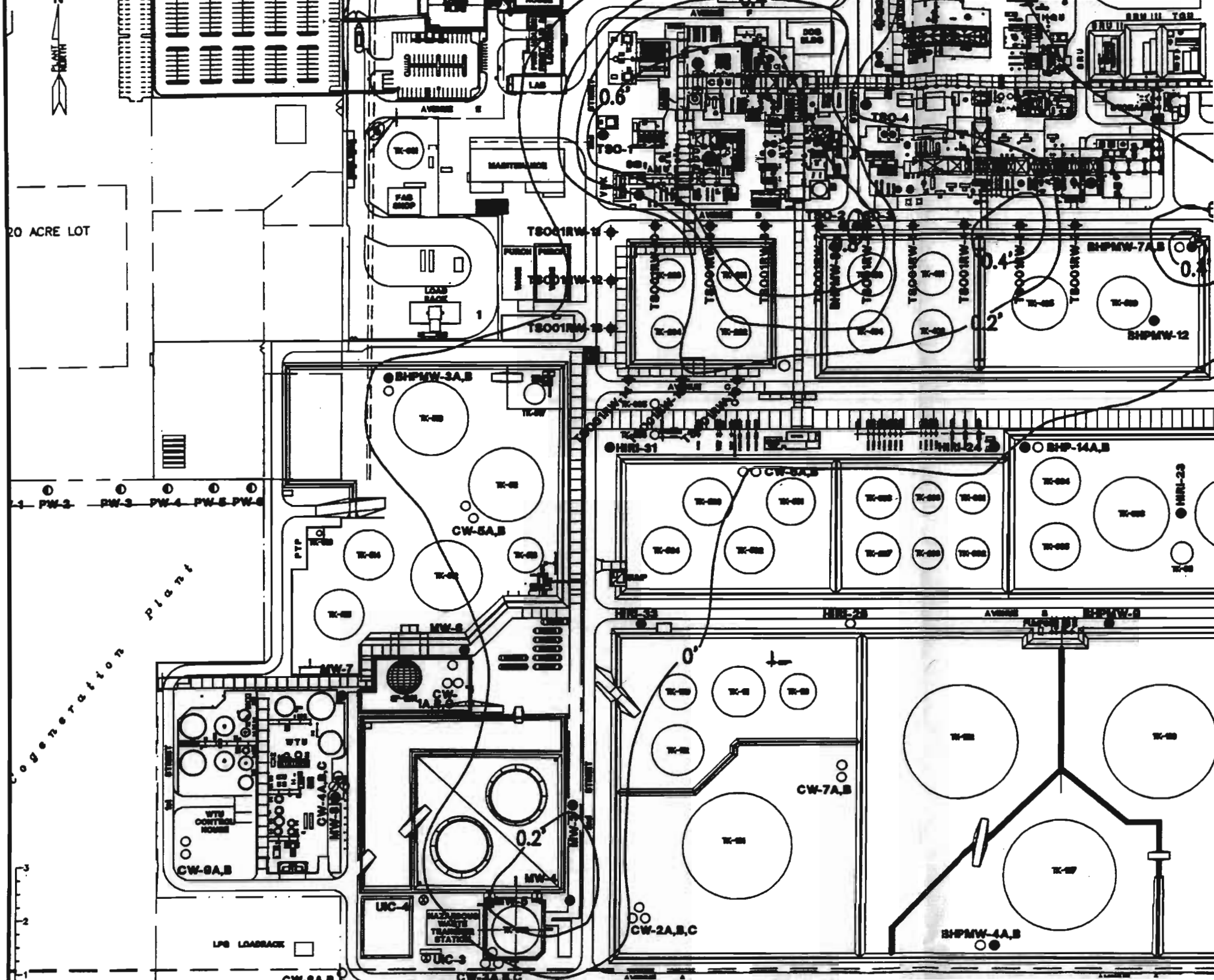
TESORO HAWAII INC.
RCRA CORRECTIVE MEASURES STUDY

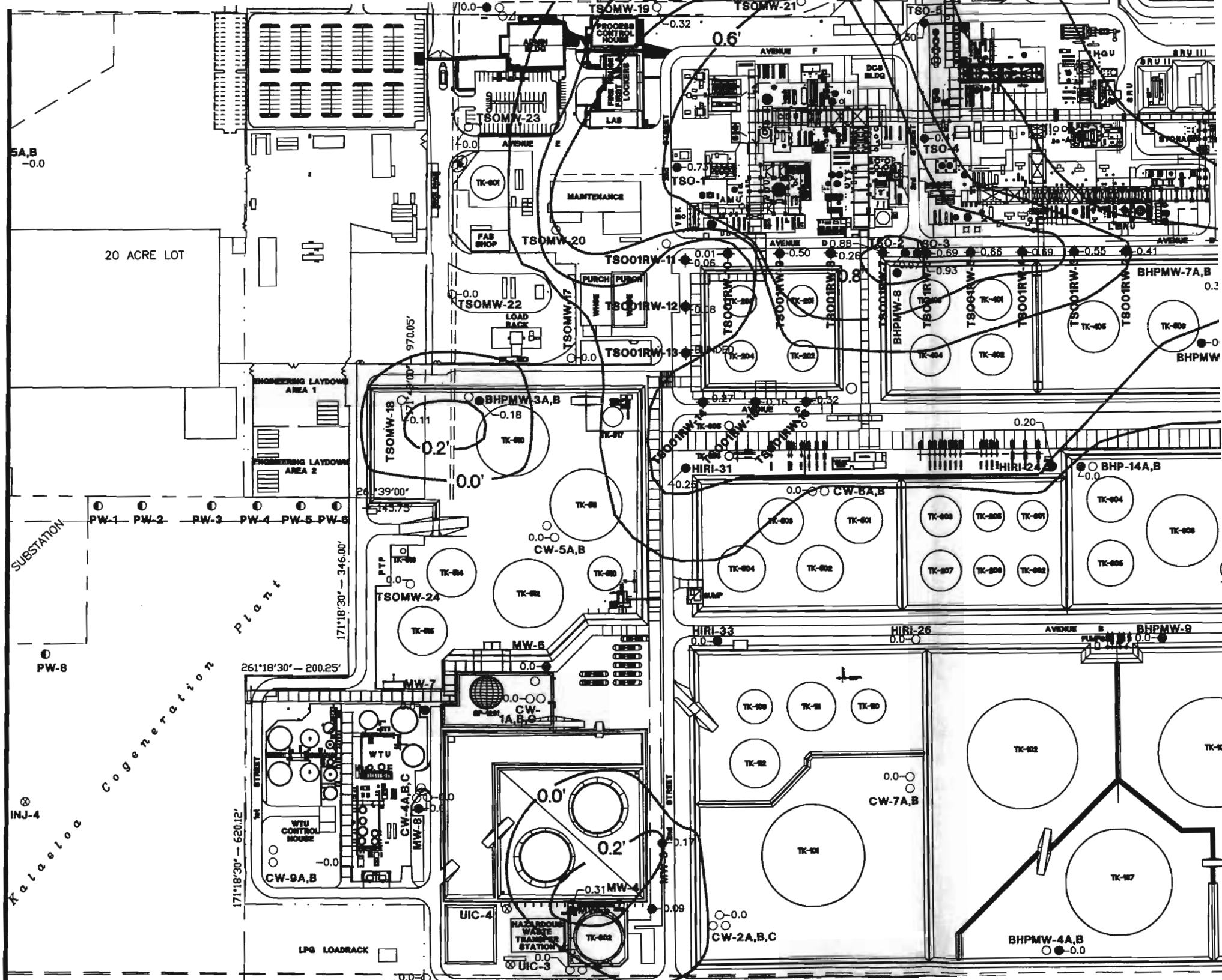
FIGURE 3

SITE PLAN

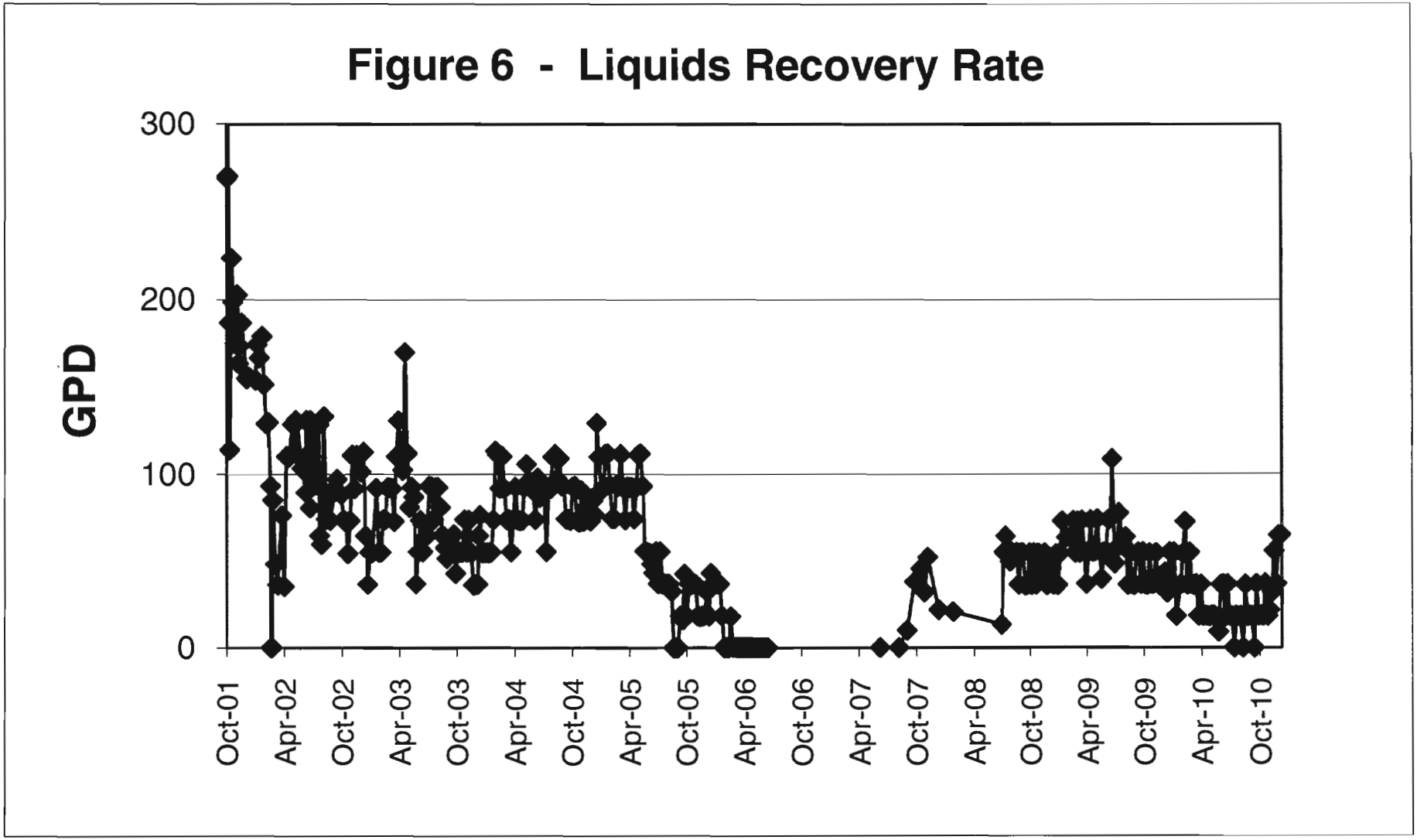
| | | | | | |
|---|---|---|---|---|---|
| NAME: | SITEPLAN.DWG | | FILE NUMBER: | A136809 | |
| 1"=350' | REVISION: 0 | DRAWN BY: | CBG | DATE: | 2-22-99 |


16
15
KALAELOA
COGENERATION
PLANT
WTU


20 ACRE LOT
Cogeneration Plant
PW-1
PW-2
PW-3
PW-4
PW-5
PW-6
BHPMW-3A,B
CW-5A,B
MW-6
MW-7
CW-1A,B
MW-4
MW-5
UIC-4
UIC-3
CW-6A,B
CW-4A,B,C
MW-3
WTB
WTB CONTROL HOUSE
LPG LOADRACK
HAZARDOUS WASTE TRANSFER STATION
CW-2A,B,C
CW-7A,B
BHPMW-4A,B
HIRI-31
HIRI-24
HIRI-23
HIRI-28
HIRI-33
BHP-14A,B
BHPMW-8
CW-8A,B
BHPMW-7A,B
BHPMW-12
TSO-1
TSO-4
TSO01RW-11
TSO01RW-12
TSO01RW-13
0.6'
0.4'
0.2'
0'
0.2'


TSOMW-19
TSOMW-21
TSO-5
TSO-4
TSO-1
TSO-2
TSO-3
TSOMW-23
TSOMW-20
TSOMW-22
TSO01RW-11
TSO01RW-12
TSO01RW-13
TSOMW-17
TSOMW-18
BHPMW-3A,B
BHPMW-7A,B
BHPMW-8
BHPMW-9
BHPMW-4A,B
HIRI-31
HIRI-24
HIRI-33
HIRI-26
BHP-14A,B
CW-5A,B
CW-7A,B
CW-2A,B,C
CW-1A,B,C
CW-4A,B,C
CW-9A,B
TSOMW-24
MW-6
MW-7
MW-8
MW-4
PW-1
PW-2
PW-3
PW-4
PW-5
PW-6
PW-8
INJ-4
UIC-4
UIC-3
20 ACRE LOT
SUBSTATION
Kalaeloa Cogeneration Plant
ENGINEERING LAYDOWN AREA 1
ENGINEERING LAYDOWN AREA 2
PROCESS CONTROL HOUSE
LAB
MAINTENANCE
FAB SHOP
LOAD RACK
WTU
WTU CONTROL HOUSE
HAZARDOUS WASTE TRANSFER STATION
LPG LOADRACK
AVENUE E
AVENUE F
AVENUE B
AVENUE C
AVENUE D
1st STREET
2nd STREET
26°39'00" — 145.75'
171°18'30" — 346.00'
261°18'30" — 200.25'
171°18'30" — 620.12'
970.05'
0.6'
0.8'
0.2'
0.0'

# Figure 6 - Liquids Recovery Rate



## Figure 7 - Cumulative Liquid Recovery (bbls)

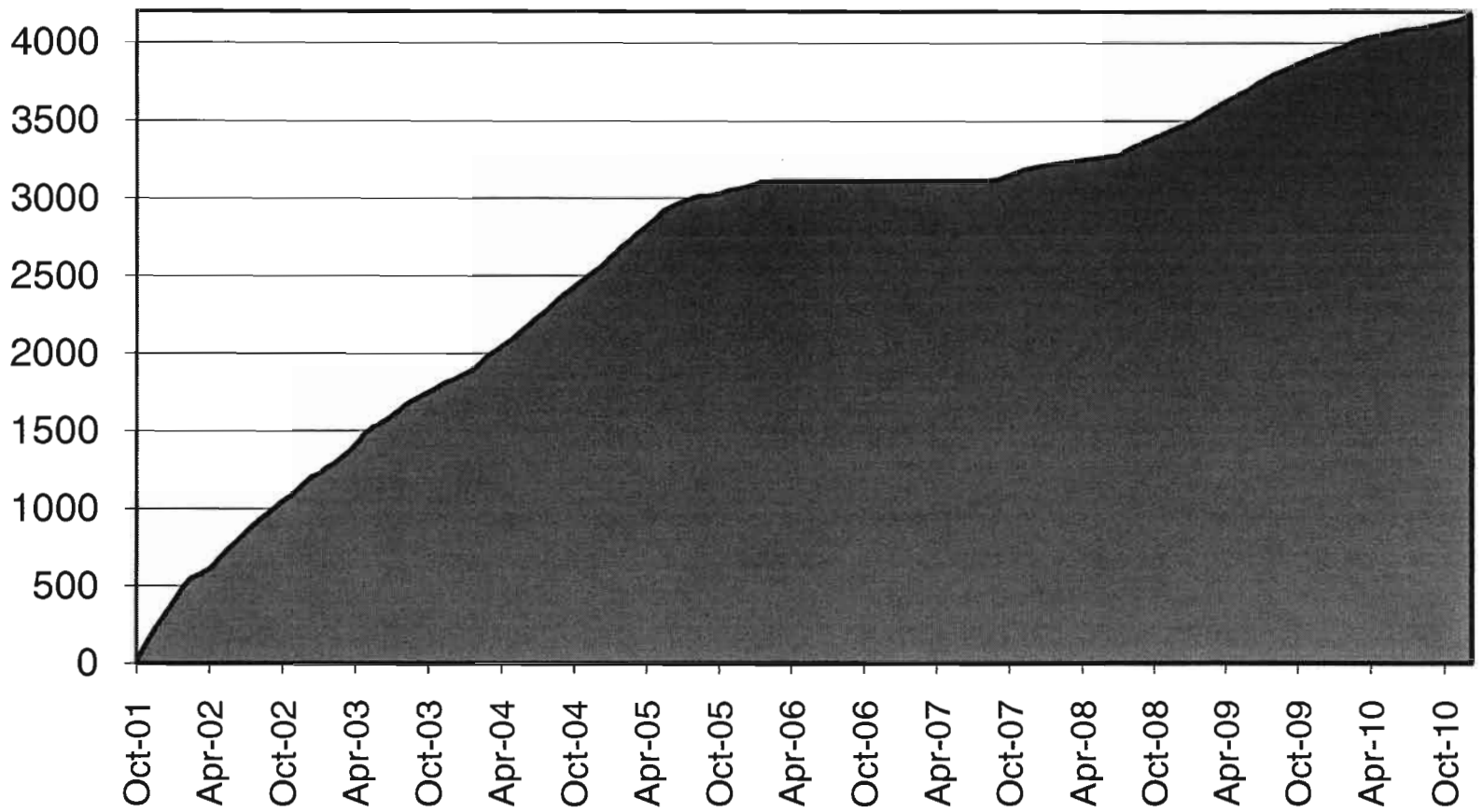


**Figure 8 - Recovery and Monitoring Wells**
**Average Thickness (ft) of 21 wells installed '99 & '01**